

The Old Rotation: Lessons Learned from a 125-Year Cover Crop Experiment

Audrey Gamble Assistant Professor, Auburn University University of Padova May 12th, 2023





Agriculture and Natural Resources in Alabama





Auburn University



Alabama Agriculture

- Agriculture exports from Alabama topped \$1 billion in 2022
- Over 38,000 farms in operation

Alabama's Top 5 Commodities:

- 1. Poultry
- 2. Cattle and Calves
- 3. Cotton
- 4. Corn
- 5. Peanut







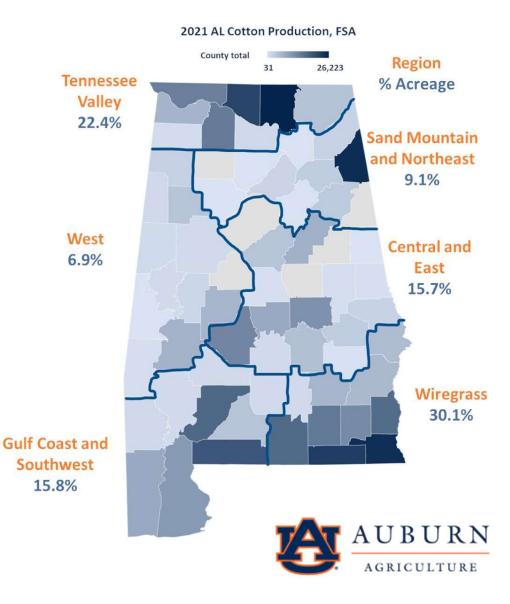






Cotton (*Gossypium hirsutum*) ~162,000 hectares









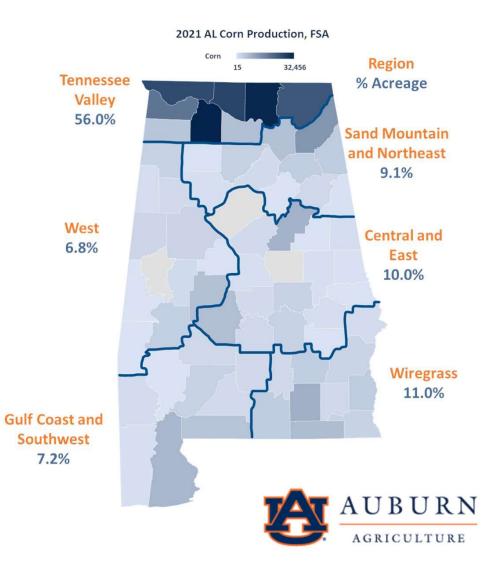




Corn (Zea mays)

~121,000 hectares

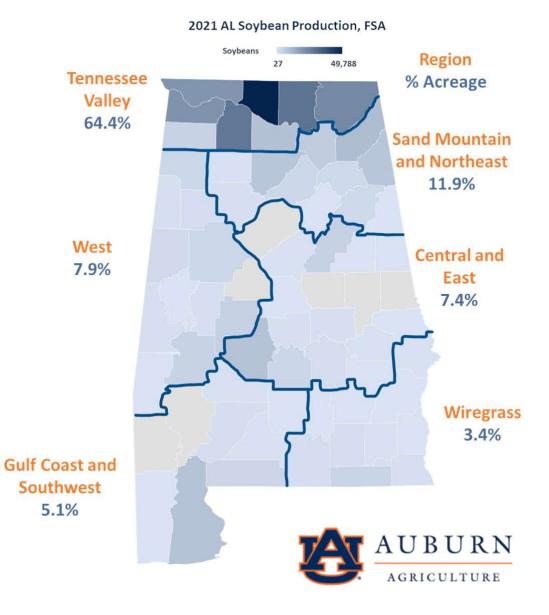




Soybean (Glycine Max)

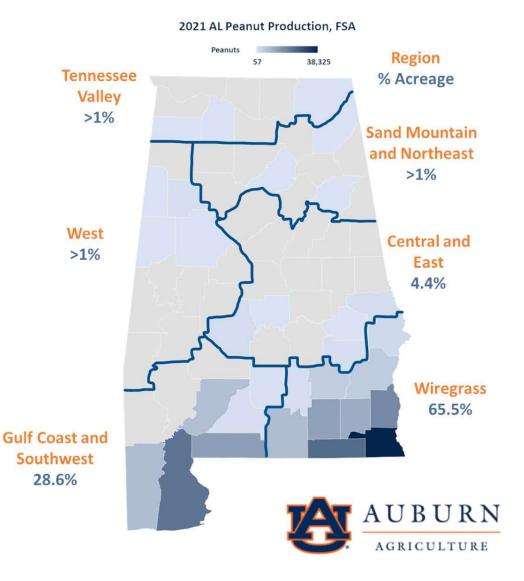
~120,000 hectares





Peanuts (*Arachis hypogaea*) ~74,000 hectares





Alabama is the No. 3 state in U.S. peanut production









12th in U.S. blueberry production



17th in U.S. peach production



6th in U.S. pecan production



2nd in U.S. catfish production



4th in U.S. lumber production



Chickens

Alabama is the No. 2 state in U.S. broiler production

1,204,700,000 Broilers!



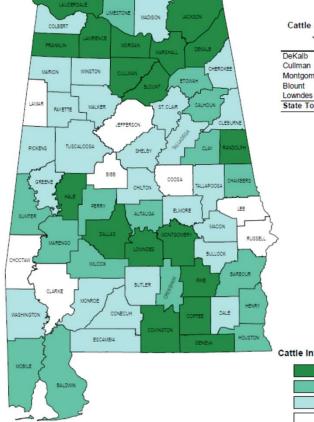


There are approximately 2,775 poultry producers in 49 Alabama counties.

Cattle

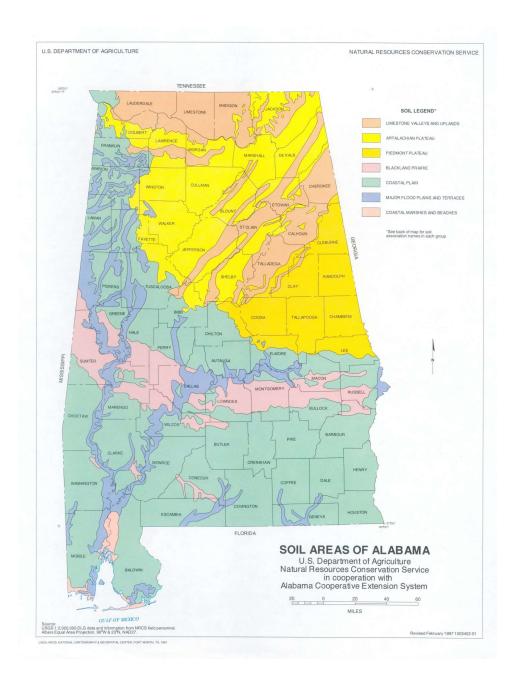
1,290,000 head of cattle and calves





Cattle and Calves on Farms January 1, 2021 Top Counties			
DeKalb	61,000	head	
Cullman	57,000	head	
Montgomery	46,000	head	
Blount	45,000	head	
Lowndes	39,000	head	
State Total	1,290,000	head	





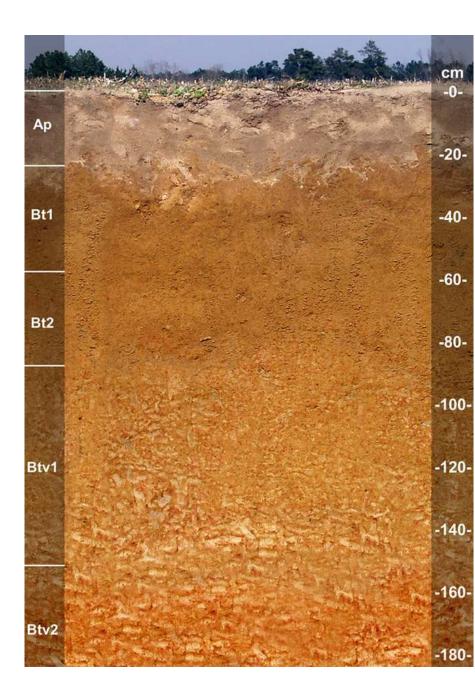
Coastal Plain

Texture:

- Sandy loam surface
- Loam or clay acid subsoils

Characteristics:

- Naturally acidic
- Well-drained
- Low in organic matter



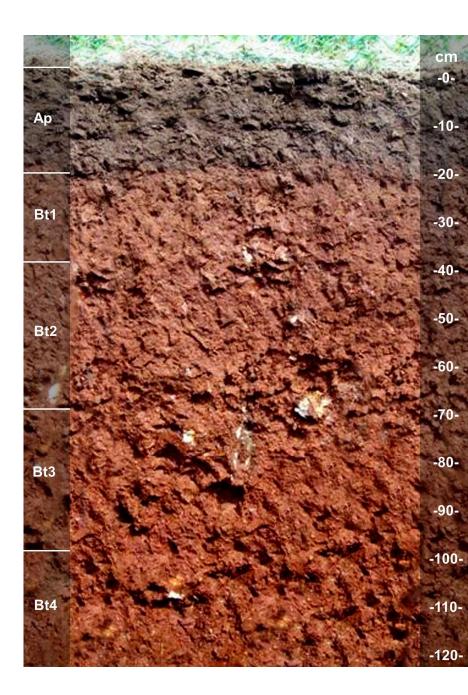
Limestone Valleys and Uplands

Texture:

- Silt loam surface
- Clay acid subsoils

Characteristics:

- Slightly acidic
- Well-drained
- Moderately permeable

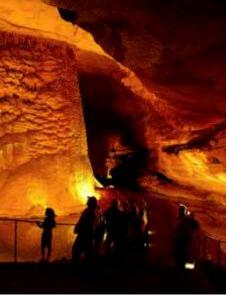


Karst and Caves in Alabama

4,200 caves have been discovered in Alabama



DeSoto Caverns, Encyclopedia of Alabama



Cathedral Caverns, Encyclopedia of Alabama



Alabama Cavefish, Encyclopedia of Alabama



Blind Cave Crayfish, Encyclopedia of Alabama

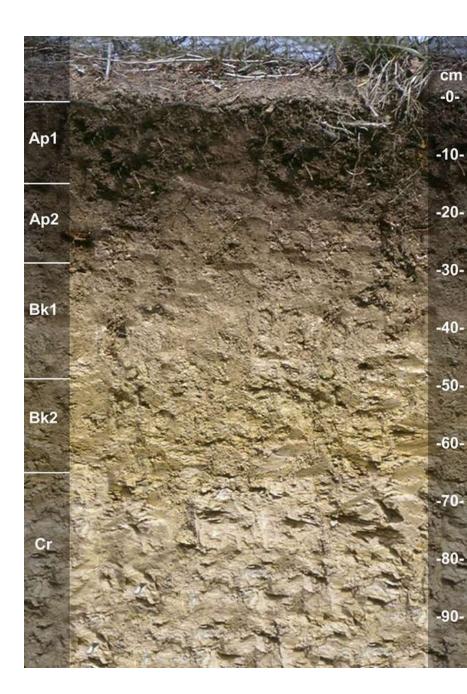
Blackland Prairie

Texture:

- Silty clay surface
- Alkaline clays weathered from calcium carbonate

Characteristics:

- Some acidic, some pH > 8
- Not well-drained
- Shrink/swell clays









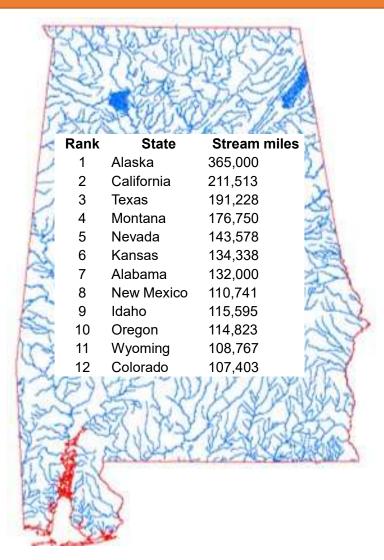
Alabama – The River State

More than 132,000 miles of streams and rivers

10% of all the freshwater in the continental U.S. originates in or flows through Alabama

Alabama has 1,438 miles of navigable rivers - more than any other state

1400 mm rainfall per year on average



America's Amazon



Alabama has more freshwater biodiversity than any other state

More than 300 species of fish (27% of North American species)

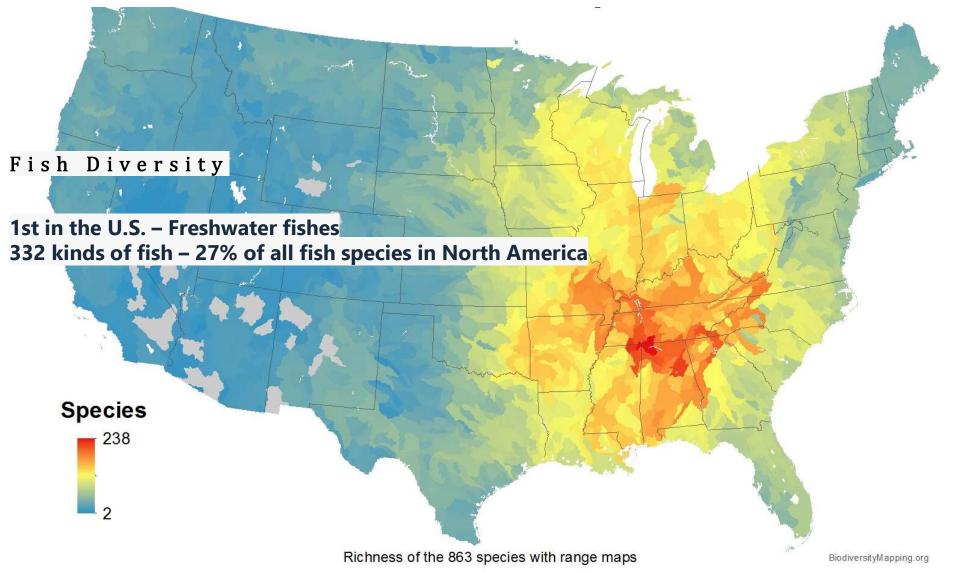
Over 99 crayfish species (22% of North American species)

61% of North American freshwater mussels

Celestial Crayfish (*Procambarus holifieldi*) Picture courtesy Dr. Rebecca Bearden, GSA



- 1st in the U.S. Turtles 27 kinds of freshwater turtles
- 57% of all turtle species in North America

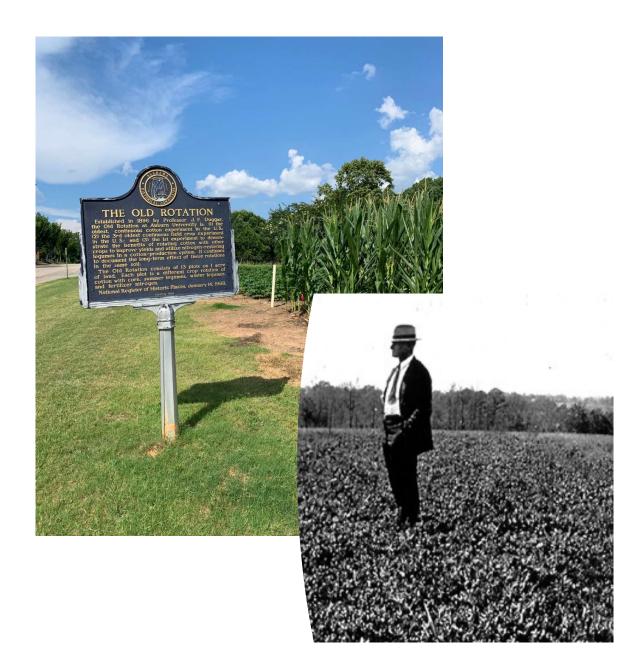


<u>U.S. protected lands mismatch biodiversity priorities</u>," by Clinton N. Jenkins, Kyle S. Van Houtan, Stuart L. Pimm, and Joseph O. Sexton. Published April 6, 2015, in *Proceedings of the National Academy of Sciences*. www.pnas.org/cgi/doi/10.1073/pnas.1418034112

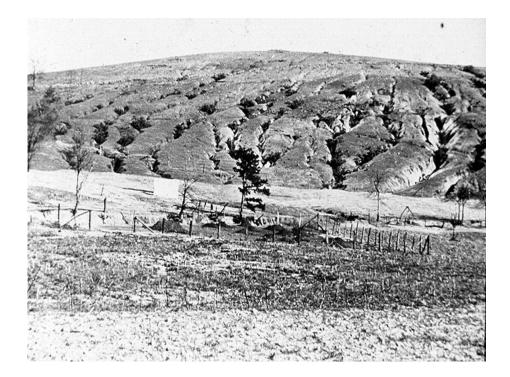


The Old Rotation

- Established in 1896
- The oldest, continuous cotton experiment in the world
- The third oldest agricultural experiment in the Unites States
- Demonstrates effect of crop rotation and cover crops on cotton yields





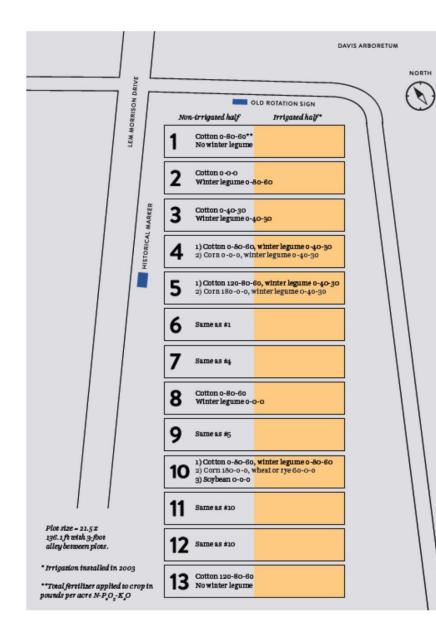




"Alabama agriculture will come into its own when her fields are green in the wintertime."

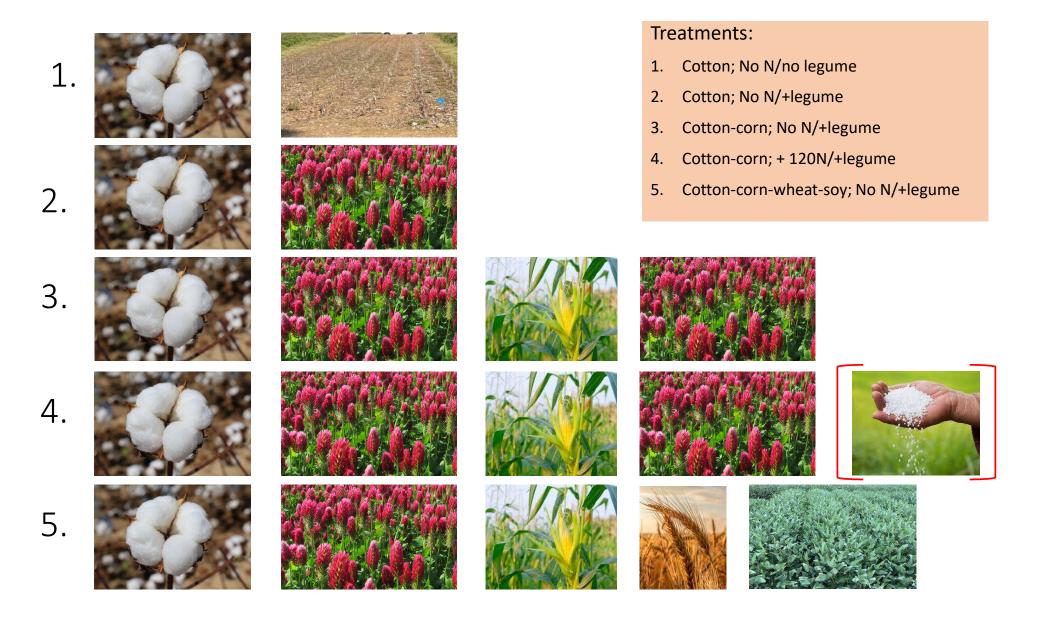
-John F. Duggar











Rotation was converted to conservation tillage in 1997





Irrigation was installed for half of each plot in 2003

			A MARINE ACTIVITY
Dryland, continuous cotton NO Winter legume cover crop NO Nitrogen fertilizer	Dryland, cotton-corn + Winter legume cover crop + Nitrogen fertilizer	Dryland, cotton-corn rotation + Winter legume cover crop NO nitrogen fertilizer	Dryland, continuous cotton + Winter legume cover crop NO nitrogen fertilizer
			Hann-
Irrigated, continuous cotton NO winter legume cover crop NO nitrogen fertilizer	Irrigated, cotton-corn + Winter legume cover crop + Nitrogen fertilizer	Irrigated, cotton-corn rotation + Winter legume cover crop NO nitrogen fertilizer	Irrigated, continuous cotton + Winter legume cover crop NO nitrogen fertilizer















		Present 1	
	PACE A LAND		
	TELEVILLE A		
	THE PARTY OF		THE LOCAL PLAN
Irrigated,	Irrigated,	Irrigated,	🔍 Irrigated, 👘 🏹
continuous	cotton-corn	cotton-corn	continuous
cotton	🕯 🕂 Winter 🛛 🤞	rotation	cotton
NO winter	🖁 legume 🍯	+ Winter	+ Winter
legume cover	cover crop	legume	legume
crop	+ Nitrogen	cover crop 🕻	cover crop
NO nitrogen	fertilizer	NO nitrogen 🕺	NO nitrogen
fertilizer	181 1914	fertilizer 🛛 🕺	fertilizer
C. 28 10 8 50 3		ART MULTIN	

Treatment	10-Year Average Lint Yield	
Continuous Cotton No Nitrogen	660 kg/ha	
Cotton-Corn w Legume Cover Crop 120 lbs N	1880 kg/ha	
Cotton-Corn w Legume Cover Crop No Nitrogen	1770 kg/ha	
Continuous Cotton w Legume Cover Crop No Nitrogen	1580 kg/ha	

*P, K, and lime applied according to soil test in all plots

Cotton as a crop does not deplete the soil or run it down excessively. The cultural practices of leaving the soil bare through the winter and not preventing erosion are responsible for the generally low fertility level of many soils on which cotton is grown.

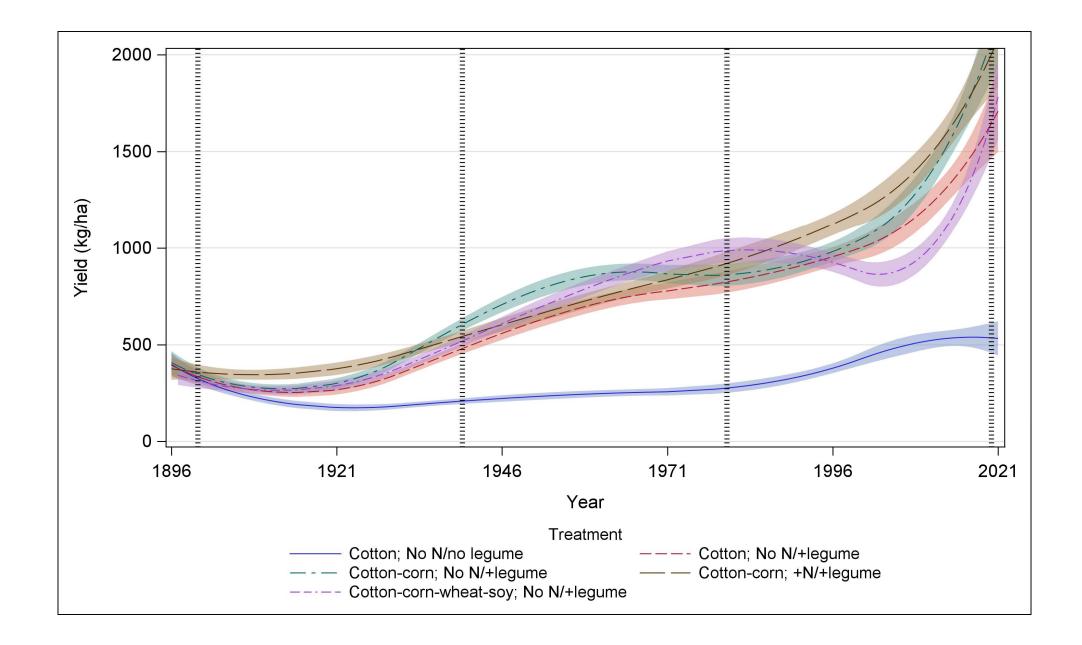
- Professor J.F. Duggar, Auburn University, 1949



225 kg =

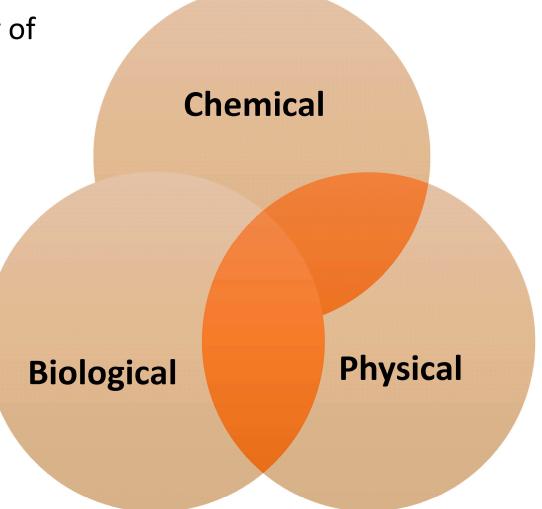






Soil health: the continued capacity of a soil to function as a vital living ecosystem, that sustains plants, animals, and humans





Functions of Soil:

- Supports Plants for Food and Fiber
- Filters Water
- Provides Habitat for Living Organisms
- Sequester Carbon
- Provide Support for Buildings/Infrastructure









Long-Term Practices to Conserve Soil and Improve Soil Health

- 1) Disturb soil less
- 2) Keep soil covered
- 3) Increase biodiversity

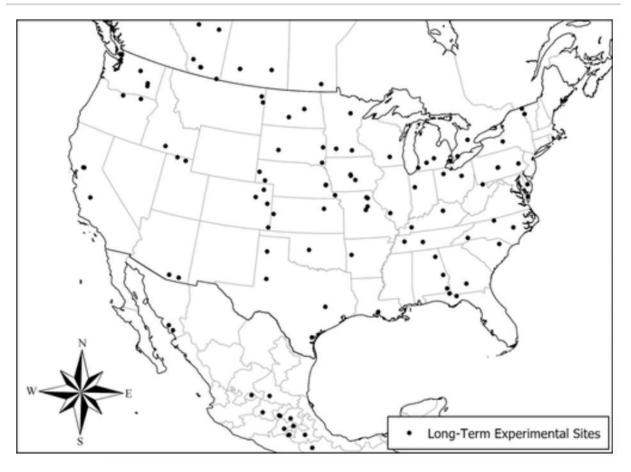








North American Project to Evaluate Soil Health







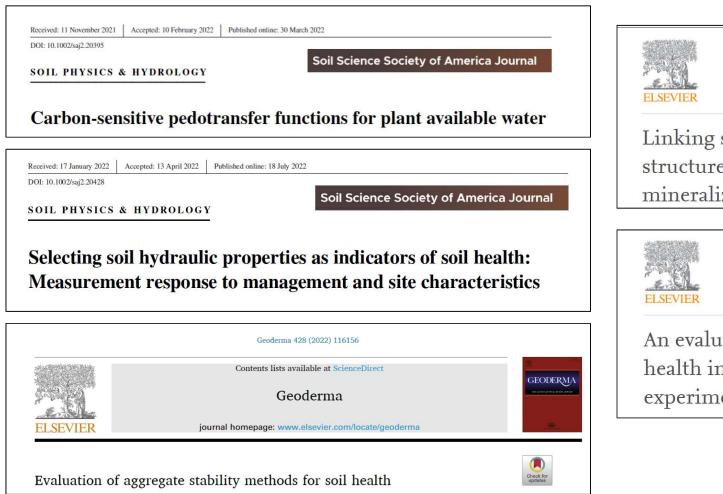


Selected Soil Health Properties for the Old Rotation

	Continuous Cotton - No Legume	Cotton-Corn Rotation w/ Winter legume
Organic Matter (%) 1.1	2.5
POXC (mg C kg ⁻¹ soil) 120	603
C Mineralization – 96 h (mg CO_2 /g dry soil / 96 hr) 0.204	0.417
β-glucosidase (mg pNP kg ⁻¹ soil hr ⁻¹) < 4.0	33.0
Total PLFA Biomass (nmol/g) 10	71
Aggregate Stability (%) 12	27
Saturated Hydraulic Conductivity (cm hr-1) 1.5	12.8
Available Water Holding Capacity (cm ³ water cm ⁻¹ soil) 0.03	0.12







Soil Biology and Biochemistry Volume 168, May 2022, 108618



Linking soil microbial community structure to potential carbon mineralization: A continental scale

> Soil Biology and Biochemistry Volume 172, September 2022, 108708



An evaluation of carbon indicators of soil health in long-term agricultural experiments











Additional Cover Crop Research in Alabama

I. Cover Crop Selection: Benefits

Small Grains (ex. Rye, Oats, Millet)

- Weed control
- Conserve soil moisture
- Improve soil organic matter
- Nutrient scavenging
- Improve water infiltration
- ErosionPrevention



Legumes

(ex. Crimson Clover, Sunn Hemp)

- Fix nitrogen for subsequent cash crop
- Erosion
 prevention
- Improve water infiltration



National Soil Dynamics Lal

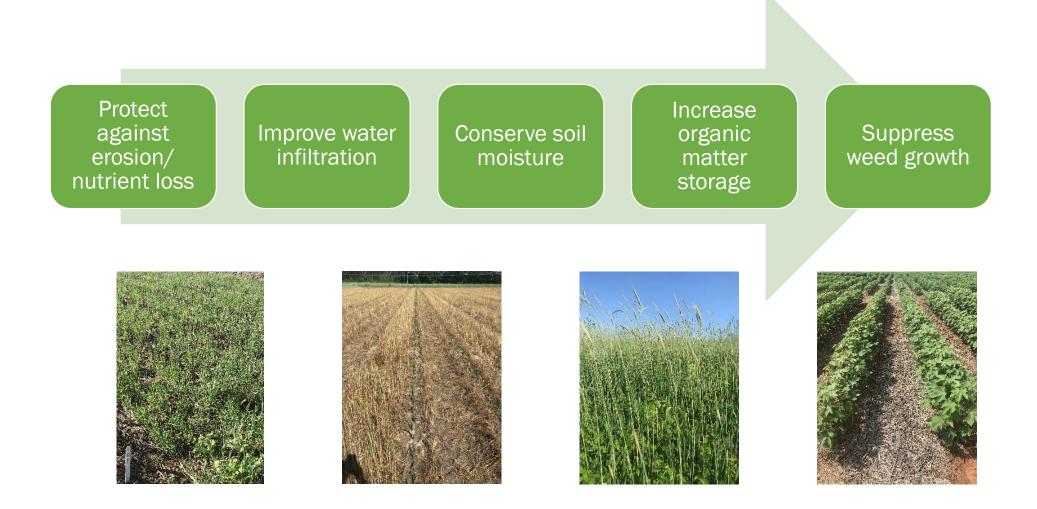
Brassicas/Other Broadleaves (ex. Tillage Radish, Canola)

- Deep taproots to break up soil compaction
- Scavenge for nutrients deeper in soil profile
- Improve water infiltration





I. Cover Crop Selection: *Benefits*









Cereal Rye (Secale cereale)





'FL401' rye, an early-maturing variety.



'Wrens Abruzzi' rye, a commonly planted variety of rye in Alabama.







Oats (Avena sativa)





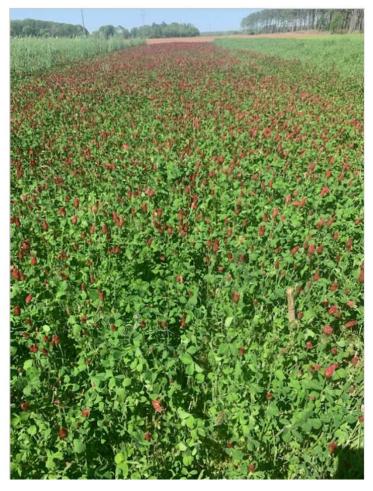


Crimson Clover (Trifolium incarnatum)





Early March 2022



Early April 2022







Hairy Vetch (Vicia villosa)





Winter Pea (*Pisum sativum* subsp. arvense)





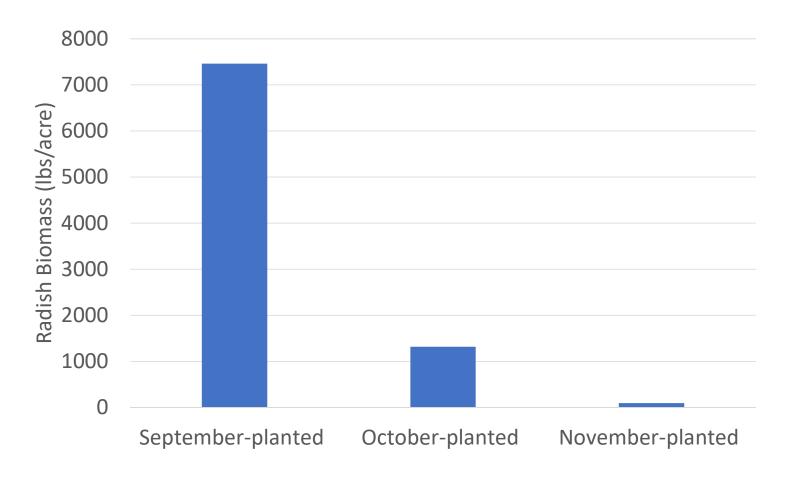


Daikon Radish (*Raphanus sativus*)



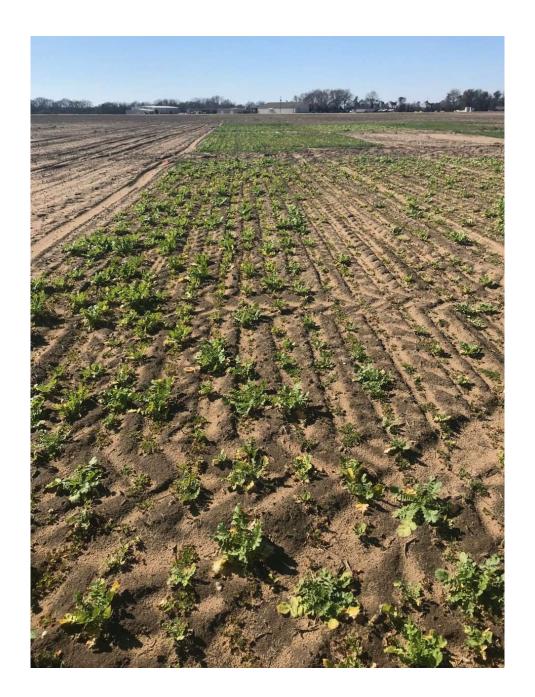
Planting Date Matters

Radish Below + Aboveground Biomass in Central and South AL





Sept-planted Daikon radish. Photo taken in Jan.









V. Current Cover Crop Research

Trials to Evaluate Cover Crop Mixtures



How do various species/mixes effect selected soil health properties and cash crop yield?

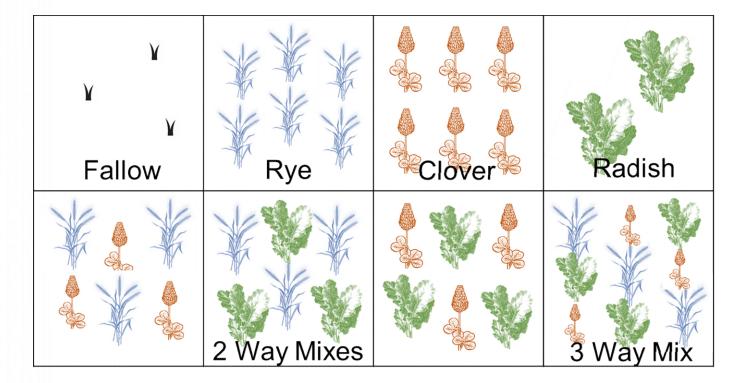




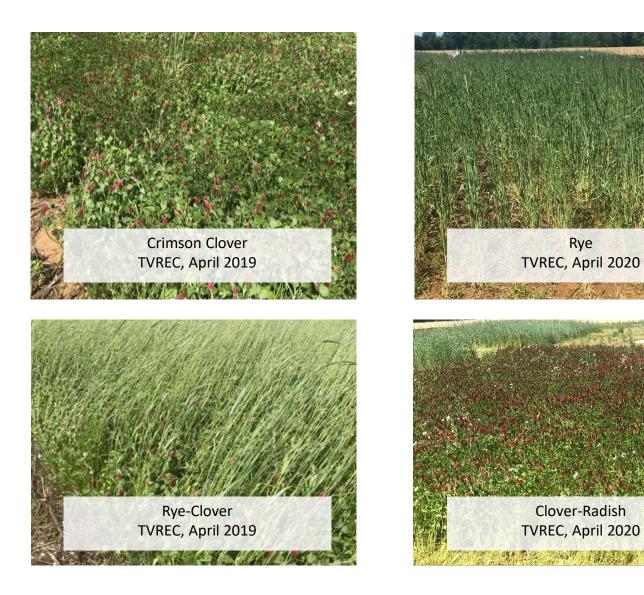




Cover Crops Evaluated

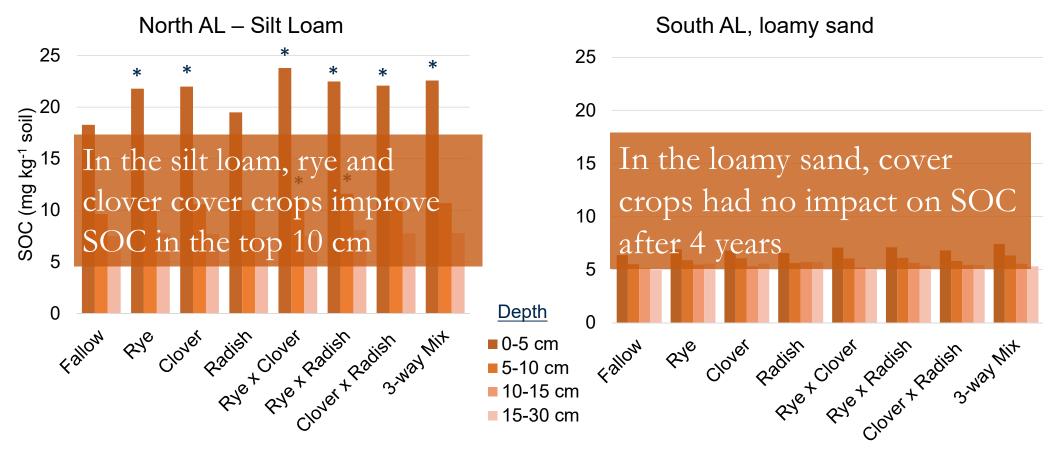




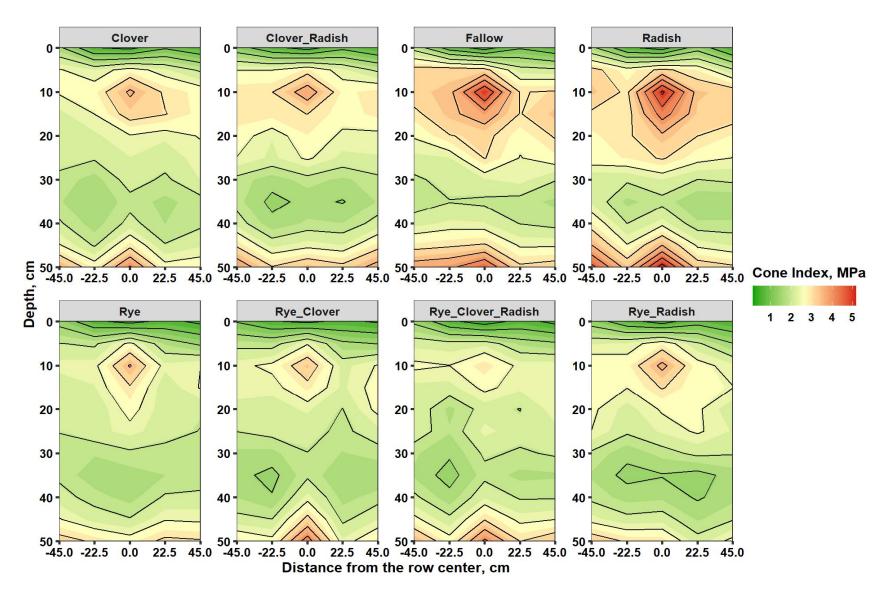


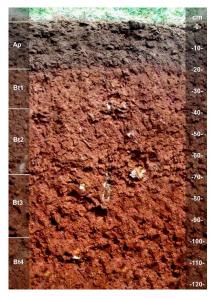


Soil Organic C (SOC)



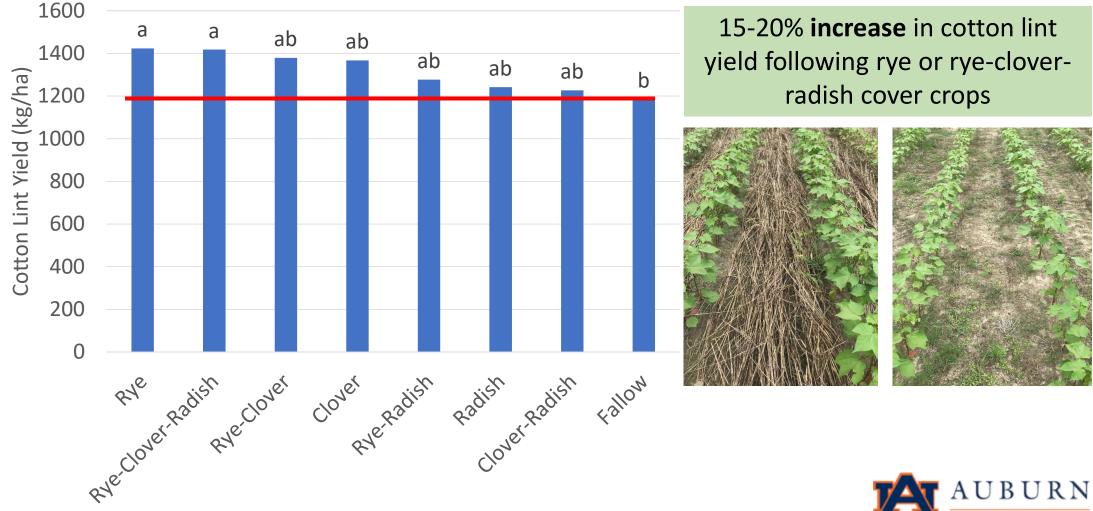
*Higher SOC than fallow at $\alpha = 0.1$







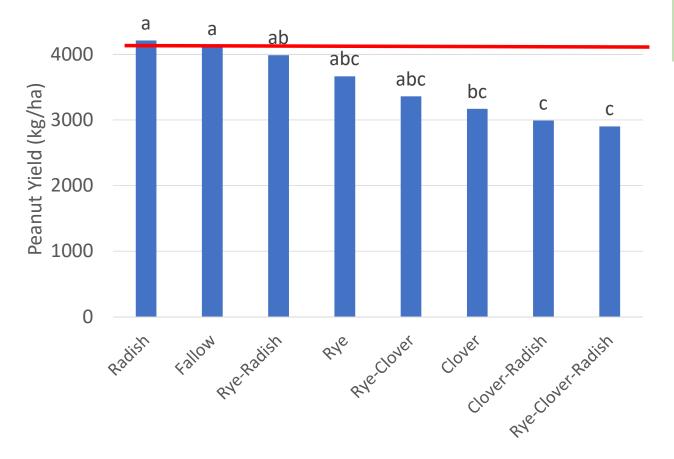




AGRICULTURE

Cotton Lint Yield – Central AL and Wiregrass 2018-2020

*Columns with the same letter do not differ between cattle removal treatments ($\alpha = 0.1$)



Peanut Yield- Wiregrass 2019

*Columns with the same letter do not differ between cattle removal treatments ($\alpha = 0.1$)

35% **decrease** in peanut yield following clover-containing cover crops





Evaluation of Cover Crop Mixtures-Conclusions

- All cover crops, except the radish monoculture, increased soil organic carbon (SOC) 19–30% in the top 5 cm at the north AL location compared with winter fallow.
- Treatments containing rye or clover decreased soil strength by 14–22% at TVREC after 4 yr of cover crop utilization.
- Short-term cover crop use improved selected soil health indicators and reversed soil degradation in the silt loam soil, but not the loam these benefits were dependent on soil type and cover crop selection.





Challenges to Implementing Cover Crops:

- Cost
- Timing of Cover Crop Planting
- Timing of Termination/Cash Crop Planting

Challenges to building soil health:

- Coarse-Textured Soils
- Climate
- Peanut Rotations



Farmer "Small Groups"







Natural Resources Conservation Service



Agricultural Research Service



ALABAMA SOIL & WATER CONSERVATION COMMITTEE





Future Directions

- Work with cover crop breeder to improve cover crop varieties
- Identify strategies to further reduce input use
- Work with farmers to implement proven practices



White Clover (*Trifolium repens*)



Audrey Gamble agamble@auburn.edu

